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Farm Pond for Development of Sustainable Irrigation and Enhancing Irrigation Resilience in Assam

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Abstract

Assam, known for its rich biodiversity and fertile land, faces significant challenges regarding Agricultural sustainability and irrigation management. The state's agriculture is predominantly rain-fed, making it highly vulnerable to the vagary's monsoon patterns. In recent years, unpredictable rainfall and water scarcity have severely threatened farmers' livelihoods, leading to declining crop yields and economic instability. Against this backdrop, farm ponds have emerged as a promising solution to improve water management, enhance irrigation resilience, and promote sustainable agriculture. This article explores how farm ponds can serve as catalysts for socio-economic development in Assam, contributing to improving irrigation practices, sustainable farming, and rural livelihood enhancement.

Keywords: Water Management, Irrigation Resilience, Sustainable Agriculture, Socio-Economic Development

1. Introduction:

The demand for water is rising quickly as a result of economic expansion, urbanization, and population rise. The biggest consumer is still agriculture, but urban and industrial demands are also growing. Existing water supplies are under stress due to this rising demand, which frequently results in over-extraction, pollution, and sectoral competition. In order to balance these demands and guarantee long-term water availability, sustainable management and effective irrigation techniques are essential to meet these escalating demands while preserving resources for future generations.

Andrea Staccioneet.el in their analysis highlights water retention ponds as beneficial for improving water availability and environmental quality in agricultural landscapes, particularly under future climate change scenarios where they can mitigate dry-season water scarcity and support higher-value agricultural production. While a greener approach to pond construction could enhance these benefits, it adds costs for farmers; thus, proposed incentive schemes aim to offset these costs, with one model focusing on social benefits and ecosystem services and the other on private-sector economic support, both fostering wider adoption of sustainable practices [1].R.S. Patodeet.el in their study demonstrates that rainwater harvesting in farm ponds can boost crop yields, water use efficiency, and income,

especially with two protective irrigations. Results show sustainable production benefits for Kharif, chickpea, and vegetable crops when stored rainwater is utilized effectively. [2]Belén López-Feliceset.el in their article aims to promote sustainable agricultural development by using Integrated Production Systems (IPS) to manage water scarcity. It highlights IPS benefits in stabilizing farmer incomes, reducing groundwater depletion, and supporting rural livelihoods. This approach balances economic, environmental, and social dimensions to ensure resources for future generations. [6].Ravinder Raju Ambati and their team in their research work in field trials from 2004-2011 in Nagpur showed that farm ponds effectively stored runoff for supplemental irrigation, enhancing Bt cotton yields by up to 50%. Minimum catchment sizes and efficient irrigation methods optimized water use for cotton, soybean, and wheat, achieving payback periods from 2 to 21 years. Supplemental recharging methods were crucial during severe droughts. [7]

2. Objective of the paper:

The objective of the paper to evaluate the role of farm ponds in addressing water scarcity, flood management, and sustainable irrigation practices for agriculture in Assam, India. By assessing crop water requirements using tools like the CROPWAT model and SWMM, the study aims to design farm ponds that optimize rainwater harvesting, runoff management, and groundwater recharge. This proactive approach helps prevent water shortages, reduces the risk of crop stress, and ultimately supports more consistent yields. It also aids in making more informed decisions about irrigation system capacity and pond storage, enhancing overall farm productivity and water conservation. This paper studies the role of government policy by examining how specific agricultural and water management initiatives support farm pond development and sustainable water use in Assam.Additionally, the paper explores farm ponds' potential for supporting livestock, aquaculture, and climate resilience, with a broader goal of enhancing agricultural productivity and socio-economic stability in rural Assam through sustainable water management practices.

3. Study Area:

Assam state is located at north east part of the India, its geographical area is 78,438 Sq.km.Assam has a tropical monsoon climate with heavy rainfall and high humidity. The rainiest month is July, and rainfall generally starts in April and continues tillSeptember. The average annual rainfall is 166 cm in Brahmaputra valley and 183cm in Barak valley. The state's agriculture is largely dependent on the southwest monsoon rains. As per Agricultural Department of Assam,present scenario of Crop water demand in Assam is Gross cropped area = 40,75,871 Ha,Net Cropped Area = 28,17,500 Ha,Irrigated Area =7,48,530HaCrop water Demand =29065 MCM, Existing Water Demand=9008MCM, Water Potential to be created=20371 MCM.[3]

Brahmaputra Basin: The total number of water bodies on WBIS in Brahmaputra Basin is 14331. Sum of the maximum water spread area of these waterbodies is 442.32 sq.km.The number of waterbodies observed for the month of Oct 2024 is 234. The sum of the actual water spread area of these waterbodies is 60.69 sq.km. against their maximum of 110.84 sq.km.

Barak and others Basin:The total number of water bodies on WBIS in Barak and others Basin is 27543. Sum of the maximum water spread area of these waterbodies is 238.57 sq.km.The number of waterbodies observed for the month of Oct 2024 is 133. The sum of the actual water spread area of these waterbodies is 48.02 sq.km. against their maximum of 58.88 sq.km.

[Source: Bhuvan portal (water body information system) (status during October 2024).]

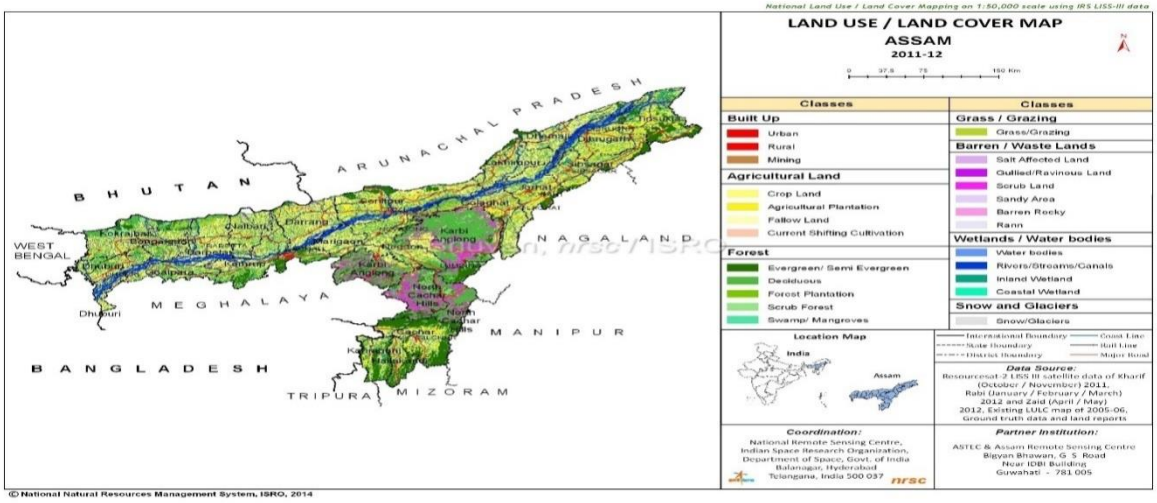

Figure 1: LAND USE /LAND COVER MAP OF ASSAM (source :Bhuvan Portal)

4. The role of Farm ponds:

The water at agricultural farm ponds comes from rainfall, runoff, the storage of reused water or the diverted of water from streams at during the maximum flow [fig.2].

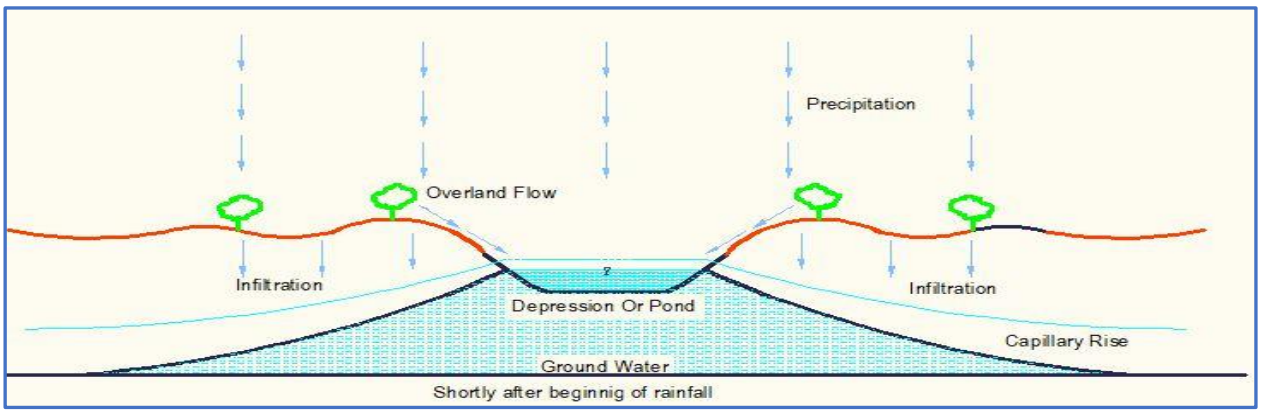

Figure 2: Water Retention Pond

The Role of Farm pond draw in fig.3 flow chart.

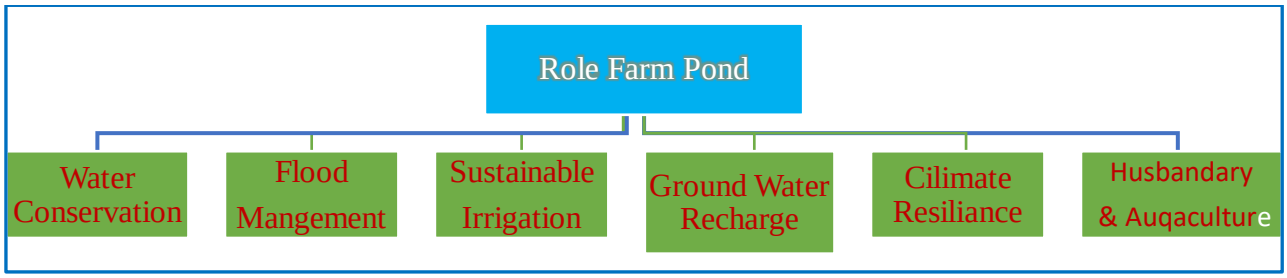

Figure 3: Flow chart for Role of Irrigation Pond (IP).

Addressing Seasonal Water Scarcity (Water Conservation): Although Assam receives abundant rainfall during monsoon (May to September), the winter and pre-monsoon seasons often experiences

water shortages due to low precipitation. Farm ponds store excess rainwater, in order to irrigate horticulture and Rabi crops, such as wheat, mustard and lentils during dry season.

Flood Management: The occurrence of flood in Assamisfrequent, particularly during the monsoon, resulting in water logging and significant crop damage. Herewith located farm ponds can store excess floodwaters, reducing the impact on agricultural land and thus minimizing the risks of soil erosion and nutrient depletion.

Sustainable Irrigation (orEnhancing Irrigation scheduling**):** Farm ponds allow farmers to practice timely irrigation, especially during critical growth stages of crops. It also allows for the introduction of efficient irrigation techniques like drip irrigation and sprinkler systems and further optimizing water usage.

Mitigating Impact of Climate change: Climate variability in Assam, including unpredictable rainfall and prolonged dry spell, affects agricultural productivity. Farm ponds offer a buffer by storing rainwater during the monsoon season in lean periods, thus reducing dependency on erratic natural water resources.

Supporting Livestock (Husbandry): In addition to irrigation, farm ponds in Assam are common, it can provide a water source for livestock, particularly during dry season when natural water level decreases. This supports the livelihood of farmers who depends on both crop production and livestock rearing.

In Assam, where both floods and water scarcity are common, farm ponds can serve as avital infrastructure for sustainable agriculture and resilient irrigation system.

Aquaculture: Assam has tradition of fish farming and farm ponds can be used for integrated farming, combining fish rearing with agriculture. This provide farmers with additional source of income and improves the efficiency of water usage. The same water can be used for irrigation after appropriate treatment.

Ground water Recharge: Farm ponds can enhance groundwater levels by allowing water to percolate into the soil. This helps maintain groundwater tables, which can later be tapped for irrigation purposes.

Suresh Kumar et.el by using SCS-CN method for runoff measurement, applied to rainfall and runoff data from Kothapally agriculture land 47 km from the Hyderabad 2006-2016, highlights the need for runoff management structures to enhance groundwater recharge, reduce soil loss, and support sustainable agricultural practices through integrated land, water, and vegetation management. [4]

4.1 Government Initiative and Policy Support:

There are various measures taken by the Indian Government to reduce the negative effects of water scarcity on the growth of Agriculture.

The **Amrit Sarovar project**, also known as Mission Amrit Sarovar, is a water conservation initiative launched by the Prime Minister of India on April 24, 2022.**Objective**: To develop or rejuvenate at least 75 ponds, or Amrit Sarovar, in each district of the country

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY): Improves water use efficiency and expand irrigated water.

Har Khet Ko Pani: provides end-to-end solutions for water storage, distribution, and efficient water use.Par drop more Crop encourage efficient water use in agriculture through technologies such as drip, sprinkler irrigation and IoT based Agriculture.

National Mission for Sustainable Agriculture (NMSA): promotes sustainable agricultural practices, including 'water use efficiency', 'Nutrient Management' and Livehood diversification''Nutrient Management' and 'Livelihood diversification'.

Atal BhujalYojana(ABHY): focuses on sustainable management of Groundwater resources to ensure water availability for future generation.

Jal Shakti Abhiyan -I: was launched in 2019 in 256 water stresses districts to promote water conservation management by focusing accelerated implementation of five target interventions, water conservation, rain water harvesting, renovation of traditional and other water bodies tanks, reuse and recharge of bore wells, watershed development and intensive afforestation.

Productivity, particularly in rainfed areas, with an emphasis on integrated farming, efficient water usage, managing soil health, and coordinating resource conservation.

By encouraging crop diversification and providing a sustainable solution to water constraint, The construction of additional farm ponds would revolutions Indian agriculture. By guaranteeing efficient implementations and beneficial effects on communities.

5. Types of Ponds:

- Excavated or dug out ponds.
- Surface ponds.
- Springs or crack ponds or embankment ponds
- Off- stream Ponds:Off-stream storage ponds are built alongside streams that only flow seasonally.
- Plastic Lined pond (plastic reduces the seepage from the pond).

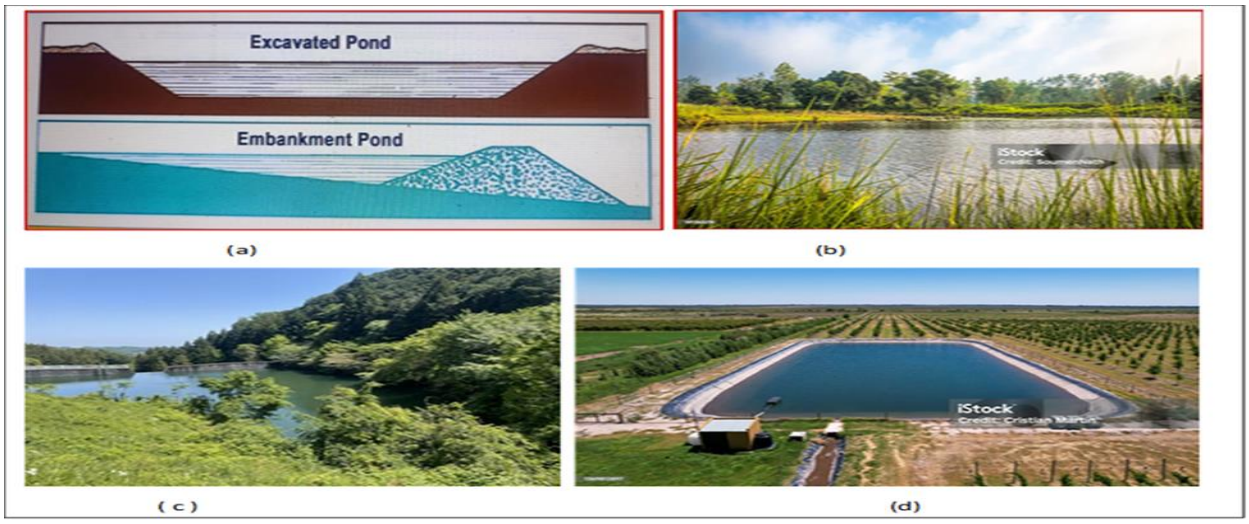

Figure 4: (a) Excavated & Embankment Pond (b) Surface Pond (c) Off-Stream Pond (d) Plastic Lined Pond

6. Methodology of Farm Pond:

Using crop data from small areas (2-4 Ha) to calculate water requirements during dry spells provides a basis for designing farm ponds that can effectively meet irrigation needs during water-scarce periods.

6.1 Software's:

In the methodology for designing and evaluating of farm ponds, software like CROPWAT, SWMM and hydrological tools play crucial roles in water resource assessment, crop water requirement and Hydrological modeling.To assess if the water stored in ponds is sufficient to meet the crop's water requirements throughout the growing season, particularly during dry spells. By comparing the available water with the crop's demand, farmers can fine-tune their irrigation schedules, ensuring they apply the right amount of water at the right time.

CROPWAT: Primarily used for calculating crop water requirement and irrigation scheduling based on climate, crop and soil data. In the context of farm ponds, CROPWAT helps in to estimate the seasonal water needs for different crops, enable more precise design of pond storage to ensure and adequate water supply for irrigation during dry spells.

SWMM (Strom Water Management Model): SWMM models uses in surface runoff, drainage and storage capacities within watersheds' farm ponds methodology, SWMM can simulate runoff and drainage patterns in and around the pond area assisting in the design of pond size, location, and overflow systems based on expected rainfall and runoff.

Aqua Crop: Models crop yield response to water, which can inform pond sizing based on expected yields and water availability.

HEC-HMS (Hydrologic modelling systems): Used for hydrological modeling of rainfall -runoff processes, supporting SWMM in more complex (Large area) watershed simulations.

WEPA (Water Evaluations and Planning): Models water allocations among competing uses and can be used to assess pond efficiency in multi-use systems.

Each software contributes to a comprehensive methodology, allowing precise calculation of pond storage needs, water availability, and sustainable crop planning in response to variable rainfall and water scarcity.

6.2 **Construction:**

The ideal farm pond size should be determined by the catchment area, hydrologicalconsideration(Precipitation, Runoff) and Soil characteristics.

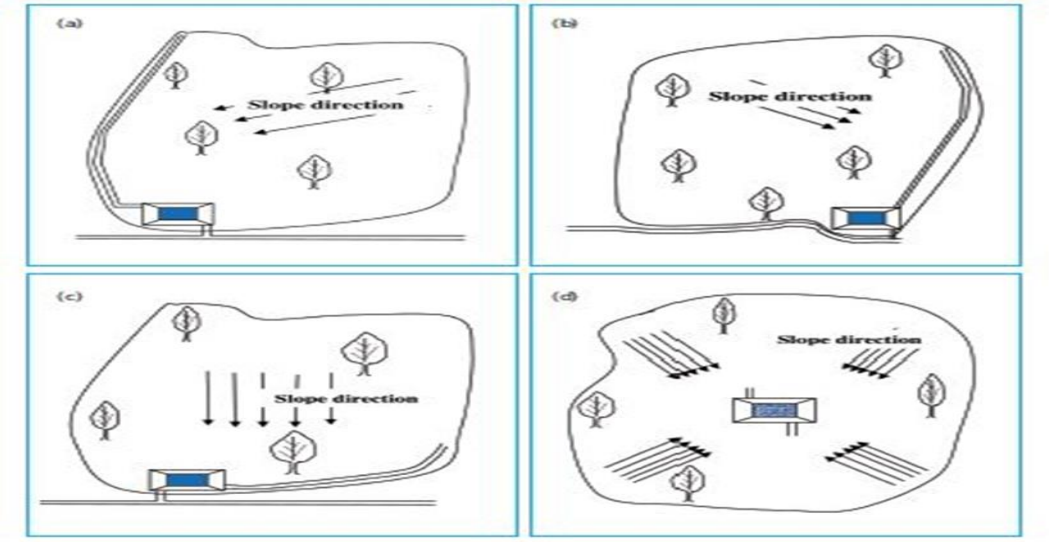

Figure 5: (figure a,b,c,d) planning and selection of site for farm ponds location in farm catchment area with different slopes. [Source: Reddy et.al]

In the event of a dry spell, the farm pond may not receive enough runoff to fill due to tiny catchment. For a use of group of people, it will be better to estimate crop water requirement of the command area for irrigation during dry spell that seasons of the crops. The management of a huge catchment pond would be also be challenging and would require a large water control structure.

6.3 Design Specification:

After determine the size and depth of the pond based on the Crop Water Requirement, Irrigation requirement, Agro climate, Rainfall patterns.

The Capacity of the pond is calculated using trapezoidal or Simpson's rule.

In trapezoidal rule, the volume of storage (V) between two successive contours is

$$\mathbf{V} = \frac{D}{2}(\mathbf{A_1} + \mathbf{A_2}) \quad \text{.....} \quad \text{Equ.1}$$

In Simpsons Rule

$$\mathbf{V} = \frac{D}{3}(\mathbf{2A_o} + \mathbf{4A_E} + \mathbf{A_1A_n}) \text{.....} \quad \text{Equ.2}$$

Where $\mathbf{A_1}$ = Area of 1st Contour, $\mathbf{A_2}$ = Area of 2nd or last Contour, $\mathbf{A_o}$=Area of Odd contour,

$\mathbf{A_E}$ = Area of Even contour, $\mathbf{A_n}$ = Area of last Contour, D= Distance between the contour

Design the inlet to entry the rainwater into the pond if require earthen or concrete bund for channeling the water should be provided.

Design outlet accordingly discharge required.

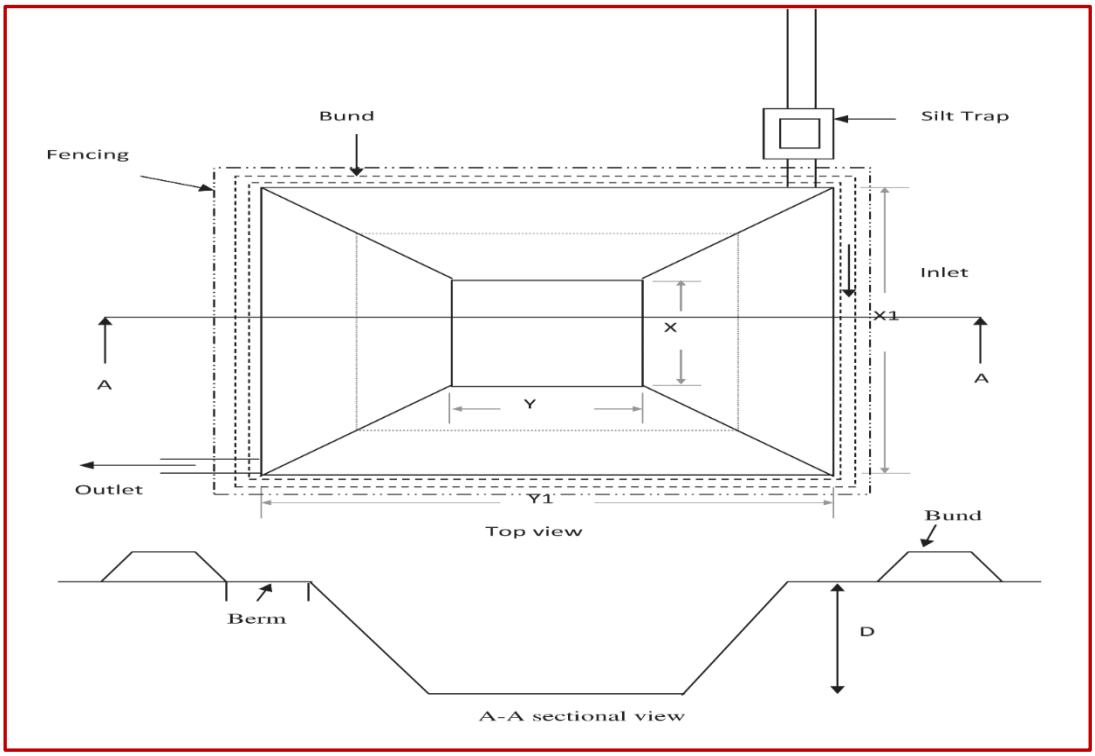

Figure 5:Lay out of diagram of farm pond. [Source: Reddy et.al]

Both manual and mechanical methods can be used to excavate within the designated pond bottom region. But in accordance with the original design and bottom should be leveled lastly by manually using the right ramming and finishing techniques.

6.4 Following point should be considered for farm pond construction:

a) Site Selection:
- Assess the land slope, Soil Type and proximity of the fields that need irrigation.
- For maximum rainwater collection and minimize excavation a low-lying area will be more suitable.
- If necessary, soil test should be done.

b) Avoid the construction of Farm pond near High Tension line for safety. And for better performance clear debris from the pond periodically. Time to time strengthening the berm of the pond,rapier leakage and erosion.

After constructing the pond every year or after every two to threeyears there shouldbe need for removing of silt or clay from the bottom of the pond and repairing of the side of berm if needed.

Figure 6:Construction of Farm pond

6.5 A comparison between Irrigation shallow tube well and farm pond:

A shallow tube well (medium and shallow) which can cover 5 to 10 Ha costs comes around 8 to 9 Lakhs for construction with additional cost of electricity bill in every month (As per Irrigation Deptt., Govt. of Assam) whereas Irrigation Ponds construction costs quite less than SHTW and there is no need for electricity bill for every month. Only annual maintenance if needed.

7. Conclusion:

Farm ponds have the potential to be game-changers for Assam's agricultural landscape. By providing a sustainable solution to water scarcity and enhancing irrigation resilience, it can also give employment to the rural youth. Farm ponds can significantly contribute to socio-economic development in rural areas. Their role in promoting sustainable agriculture, improvinglivelihoods, and fostering community resilience makes them a critical tool for addressing the challenges faced by Assam's farmers. With continued government support and farmers participation, farm ponds can serve as a catalyst for a more prosperous and sustainable future for Assam's agricultural communities.Strategic crop selection can also lead to improved productivity, better income generation, and long-term resilience against water scarcity. With strategic implementation, farm ponds can drive a shift towards sustainable agriculture, support water conservation, contribute to socio-economic upliftment of Assam's rural communities', creating a path towards a more resilient and productive agriculture future.

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